# RECENT SUBSIDENCE IN THE SACRAMENTO/SAN JOAQUIN DELTA REVEALED BY SPACE-BASED GEODESY

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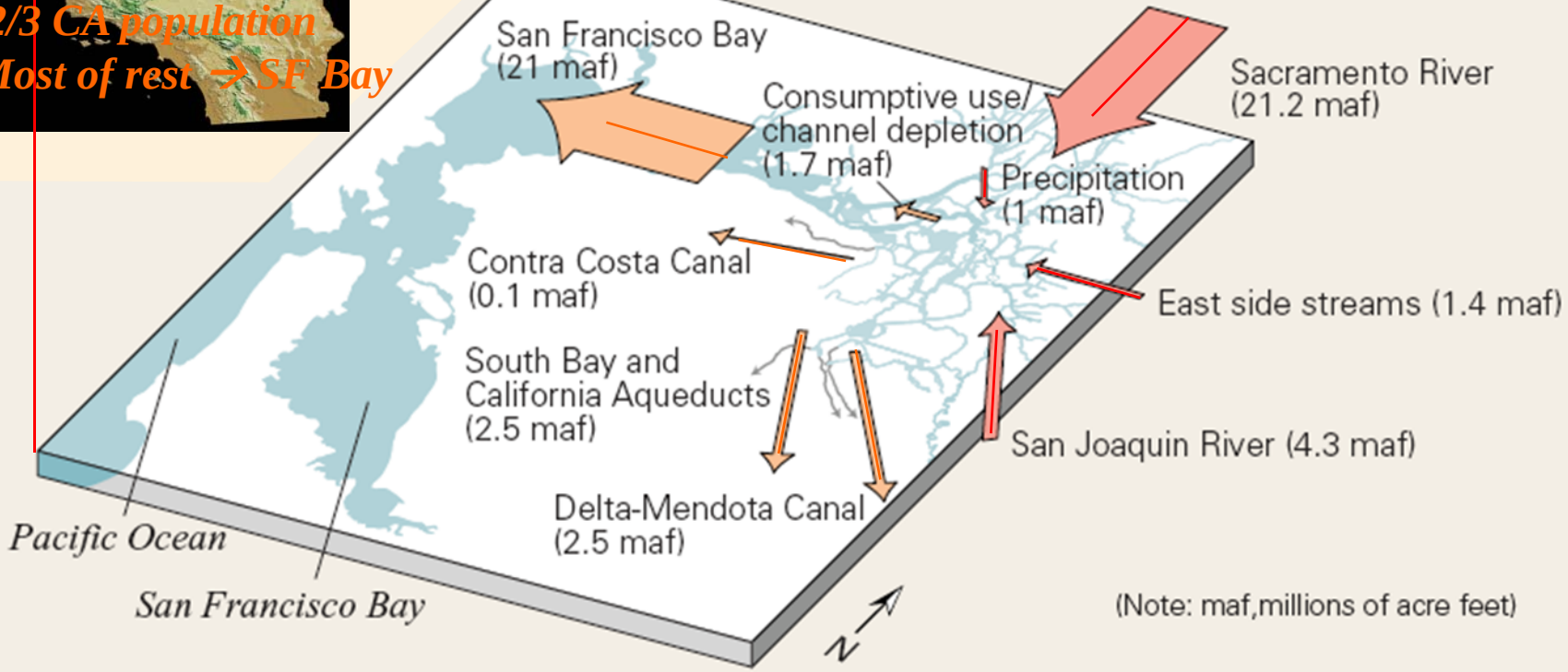
# SACRAMENTO-SAN JOAQUIN DELTA & CALIFORNIA WATER BUDGET

## ANNUAL OUTFLOW

- *25% inflow → CA water system*
- *Portion of drinking water for ~ 2/3 CA population*
- *Most of rest → SF Bay*

## ANNUAL INFLOW

- *40% CA land area runoff*
- *50 % CA total streamflow*




*From Ingebretsin et al., 2000; USGS report*

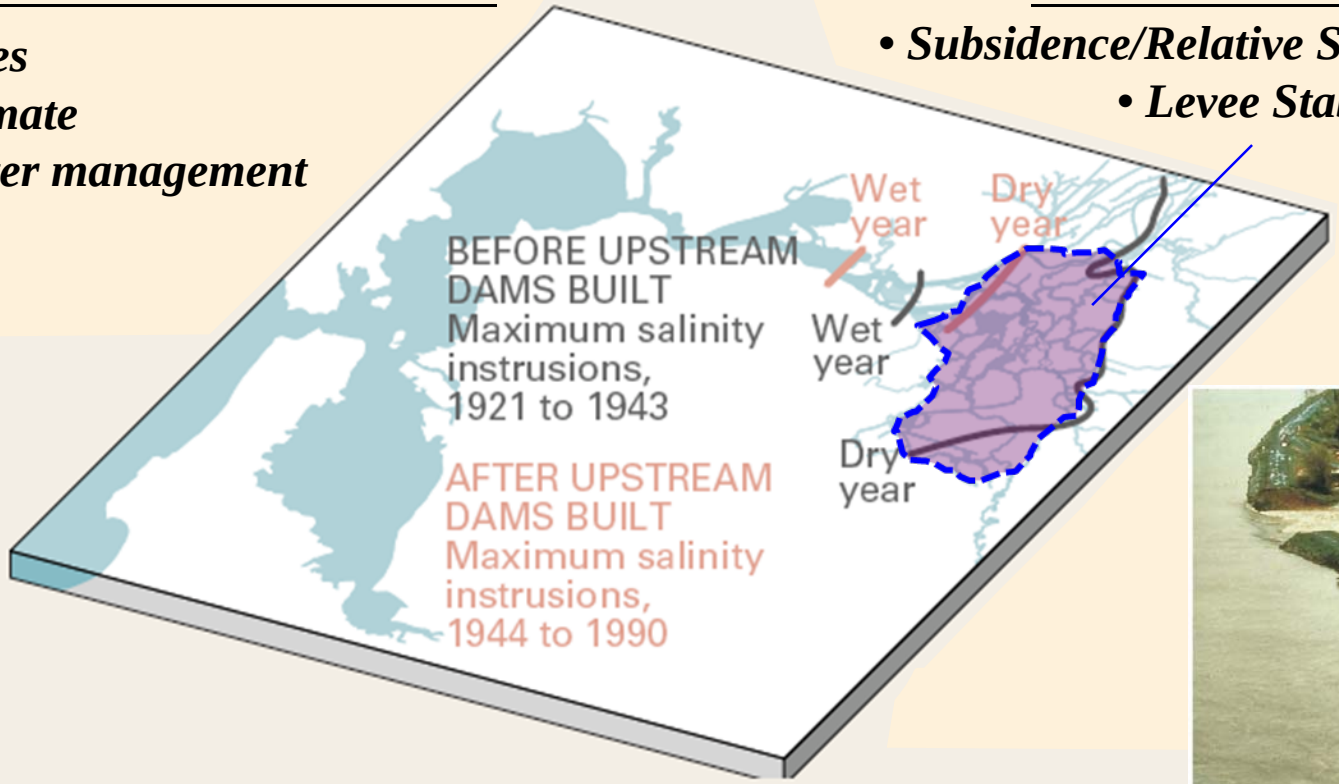
# FRESH WATER QUALITY & DELTA ISLANDS

## SALINITY INTRUSIONS

- *Tides*
- *Climate*
- *Water management*

## DELTA ISLANDS

- *Subsidence/Relative Sea Level Change*
- *Levee Stability*




*From Ingebretsin et al., 2000; USGS report*

# DELTA ISLANDS & SEA LEVEL

*Most of these areas are currently protected by levees. They would be inundated only if those levees fail or are overtopped.*

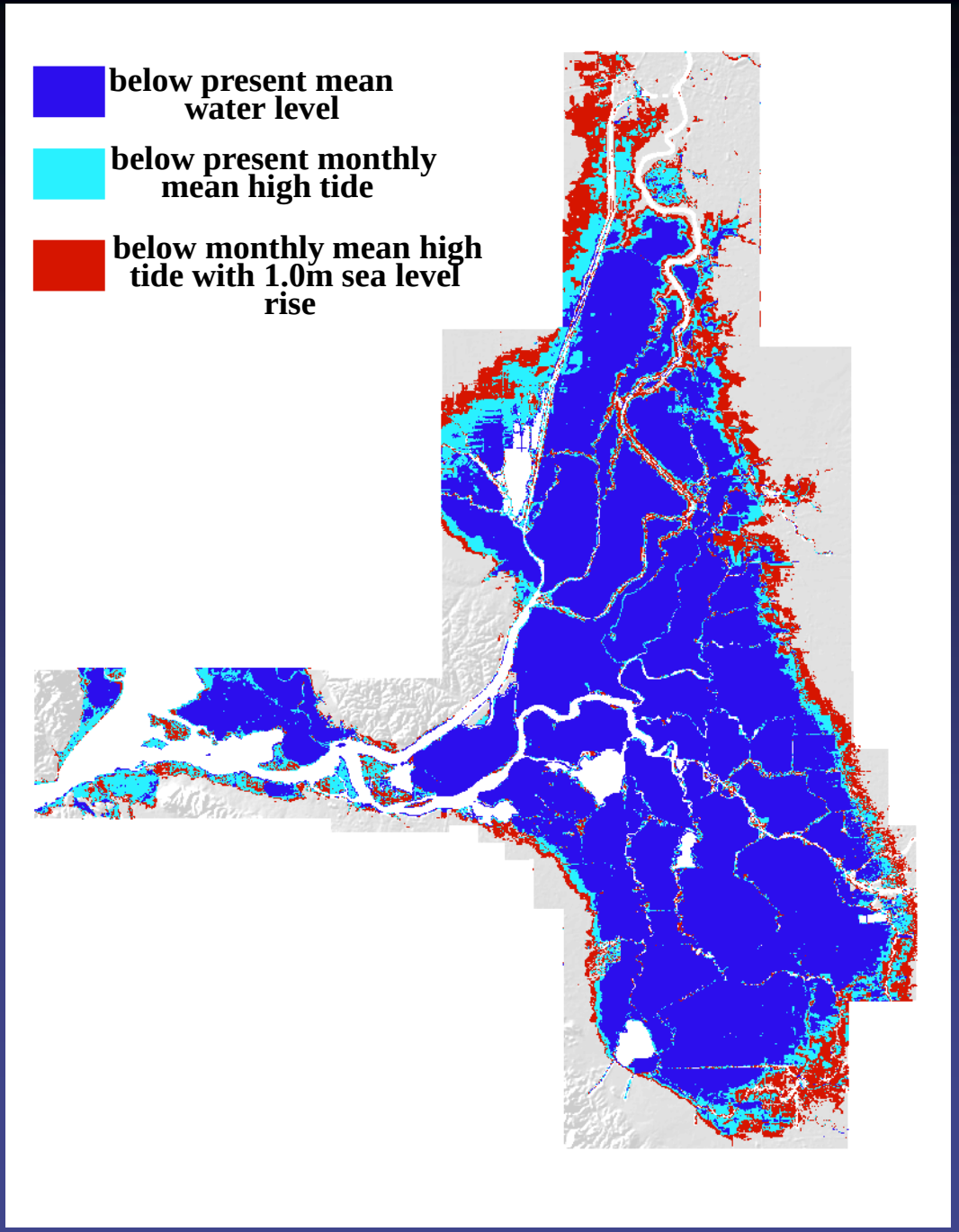
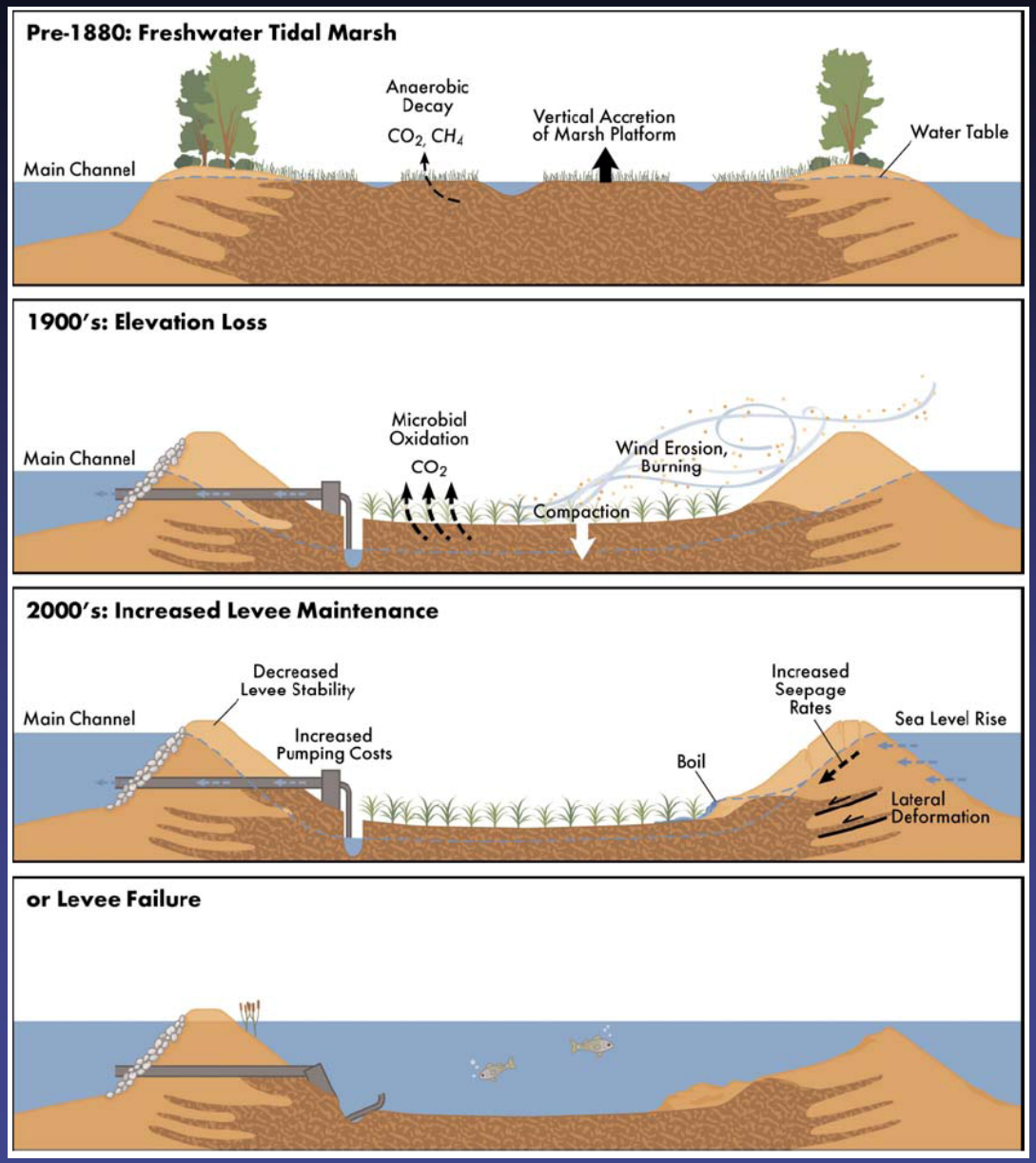



Figure courtesy Noah Knowles, USGS

# ISLAND EVOLUTION, SUBSIDENCE, AND LEVEES

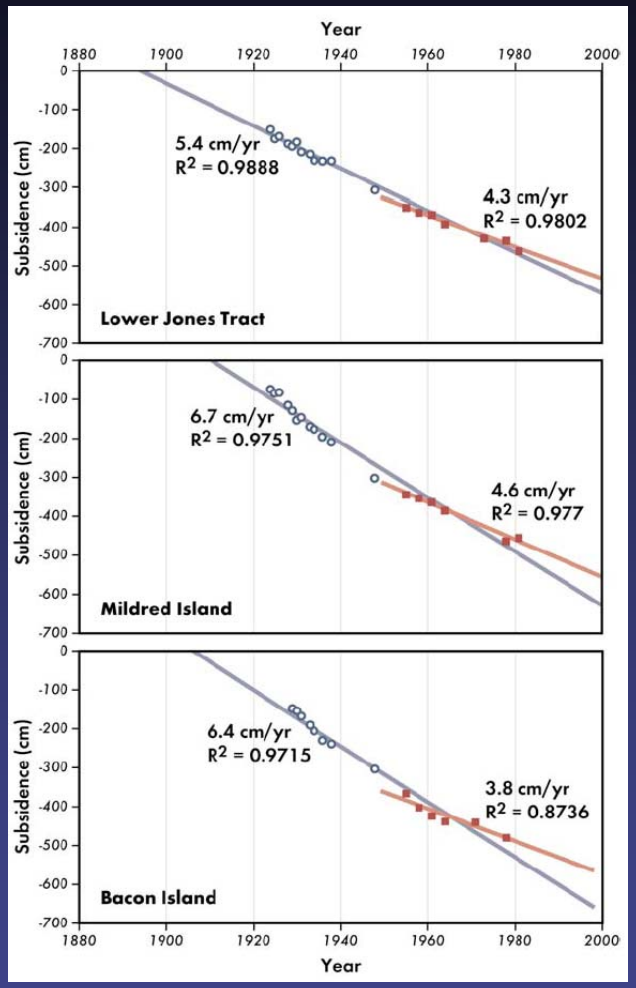
Island draining for agricultrural purposes → compaction and elevation loss.




**Sea level rise, ageing levees, continued (though slowed) subsidence → risk to fresh water quality.**

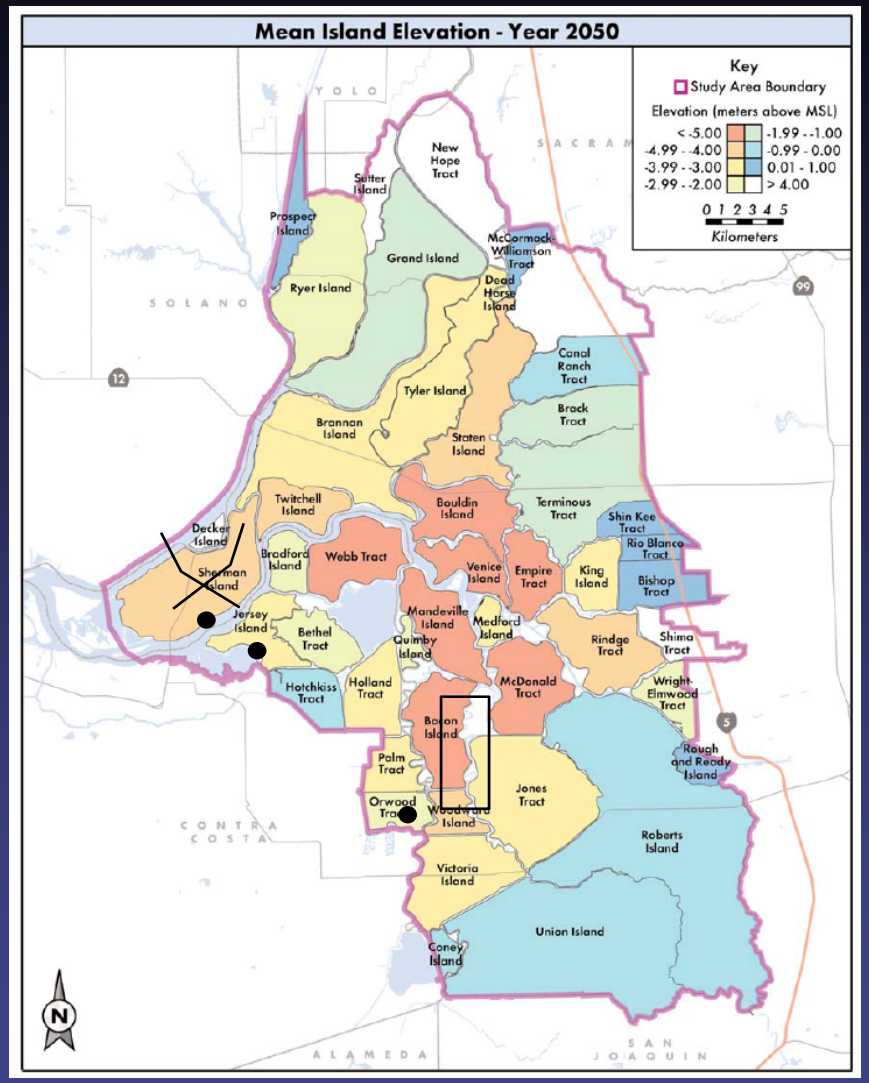
*From Mount and Twiss, 2005*

# 50 YEAR PROJECTION




*From Mount and Twiss, 2005*

Based on leveling & point measurements (*Deverel & Rojstaczer, 1996; Rojstaczer & Deverel. 1995)* and regional topographic analysis




NEED FOR SYNOPTIC, HIGH RESOLUTION MEASUREMENT/ MONITORING OF DELTA SUBSIDENCE

# SPACE-BASED GEODESY:

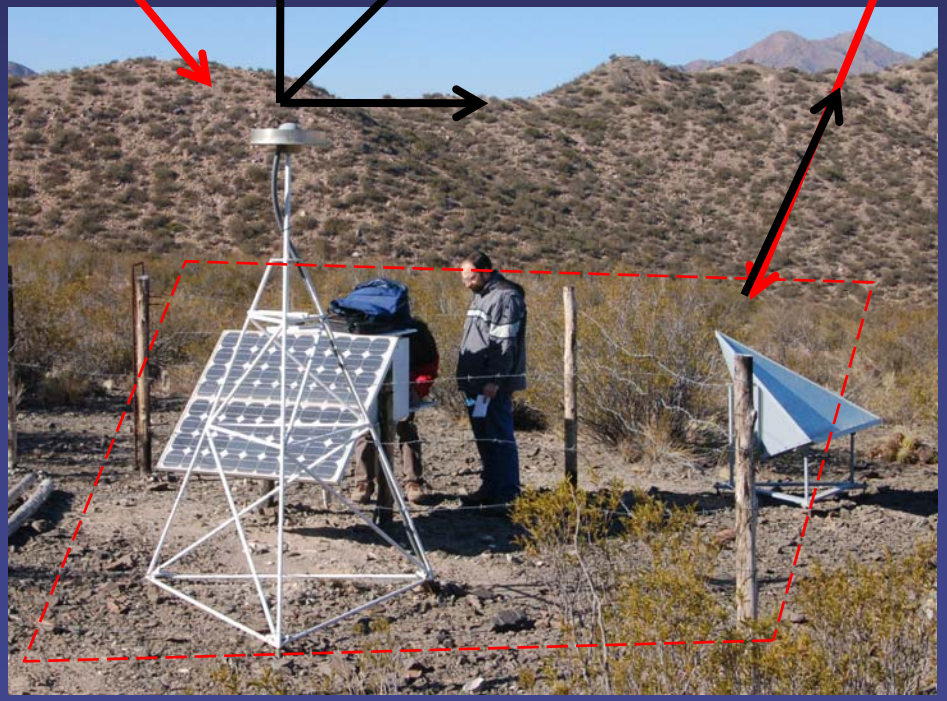
## GPS AND INSAR (SYNTHETIC APERTURE RADAR INTERFEROMETRY)

GPS network:
continuous operation

*3 components*
*(NEU)*

SAR
satellite:
repeat orbits

*1 component*
*(LOS – line of sight)*

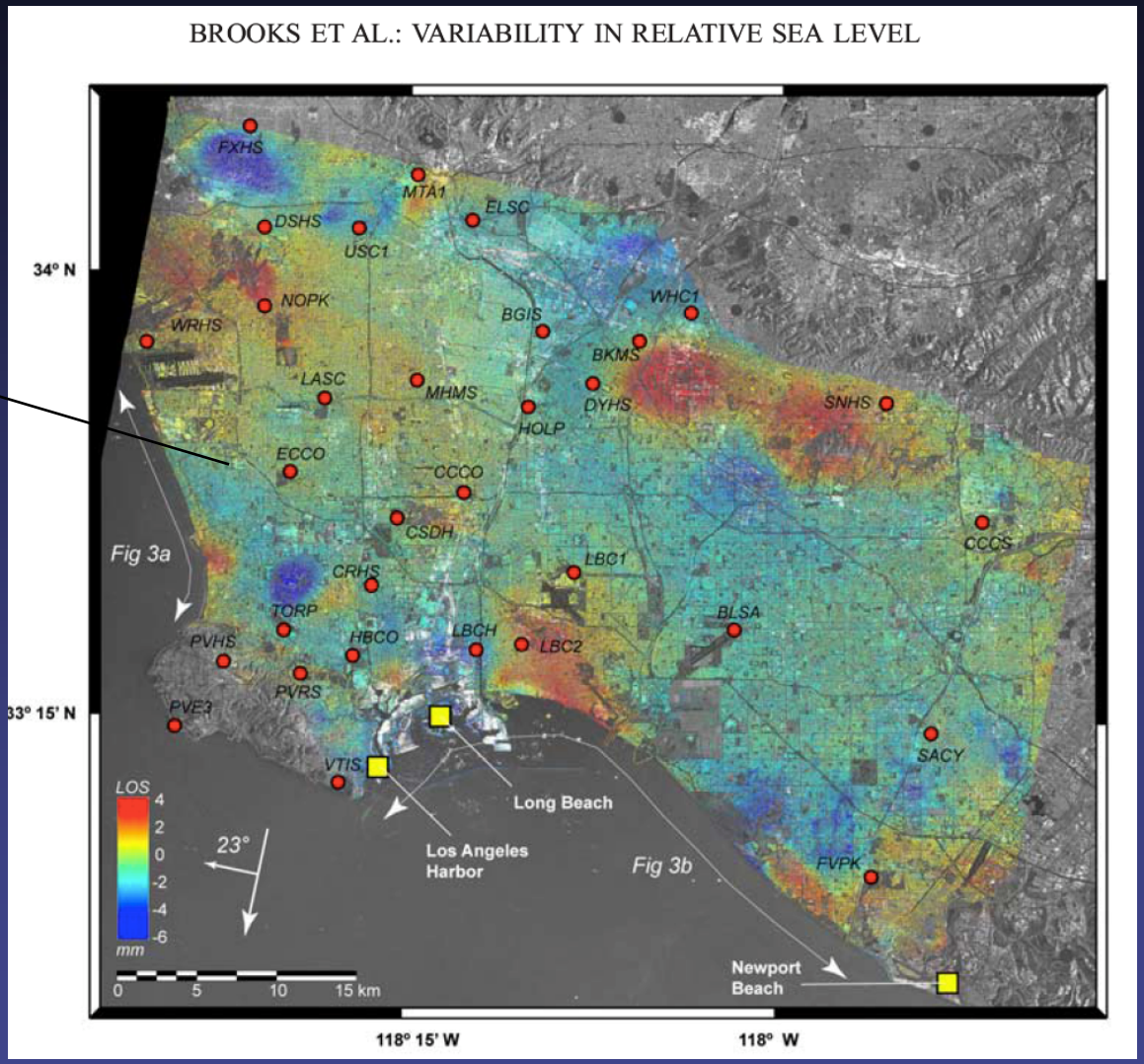


- *mm-scale resolution*
- *errors: atmospheric and ionospheric*

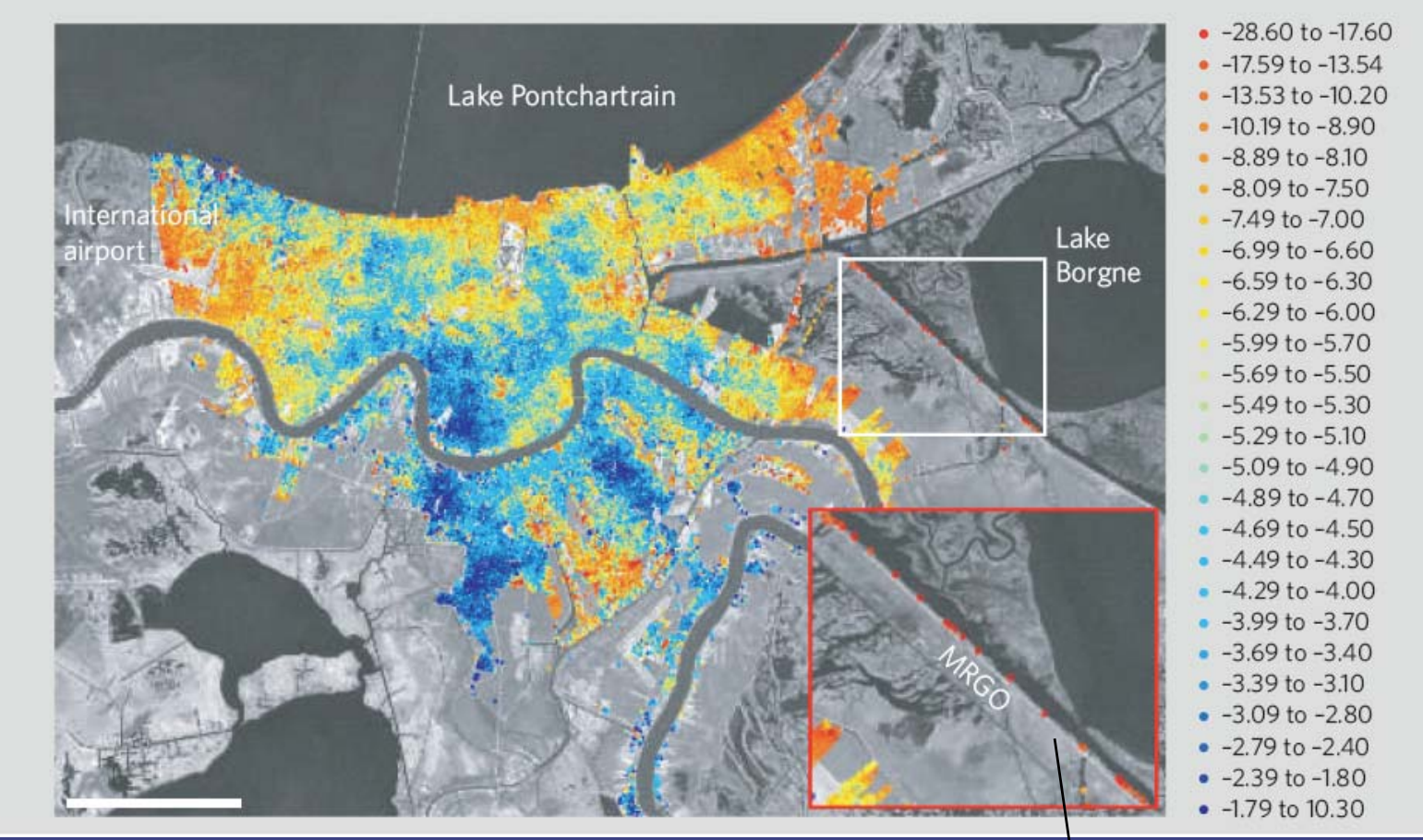
*GPS: temporal coverage*
*InSAR: spatial coverage*

# INSAR AND SEA LEVEL CHANGE

Persistent Scatterer (PSInSAR) technique to take advantage of stable scattering targets like buildings and road guard rails.



# PSINSAR AND LEVEE STABILITY: NEW ORLEANS

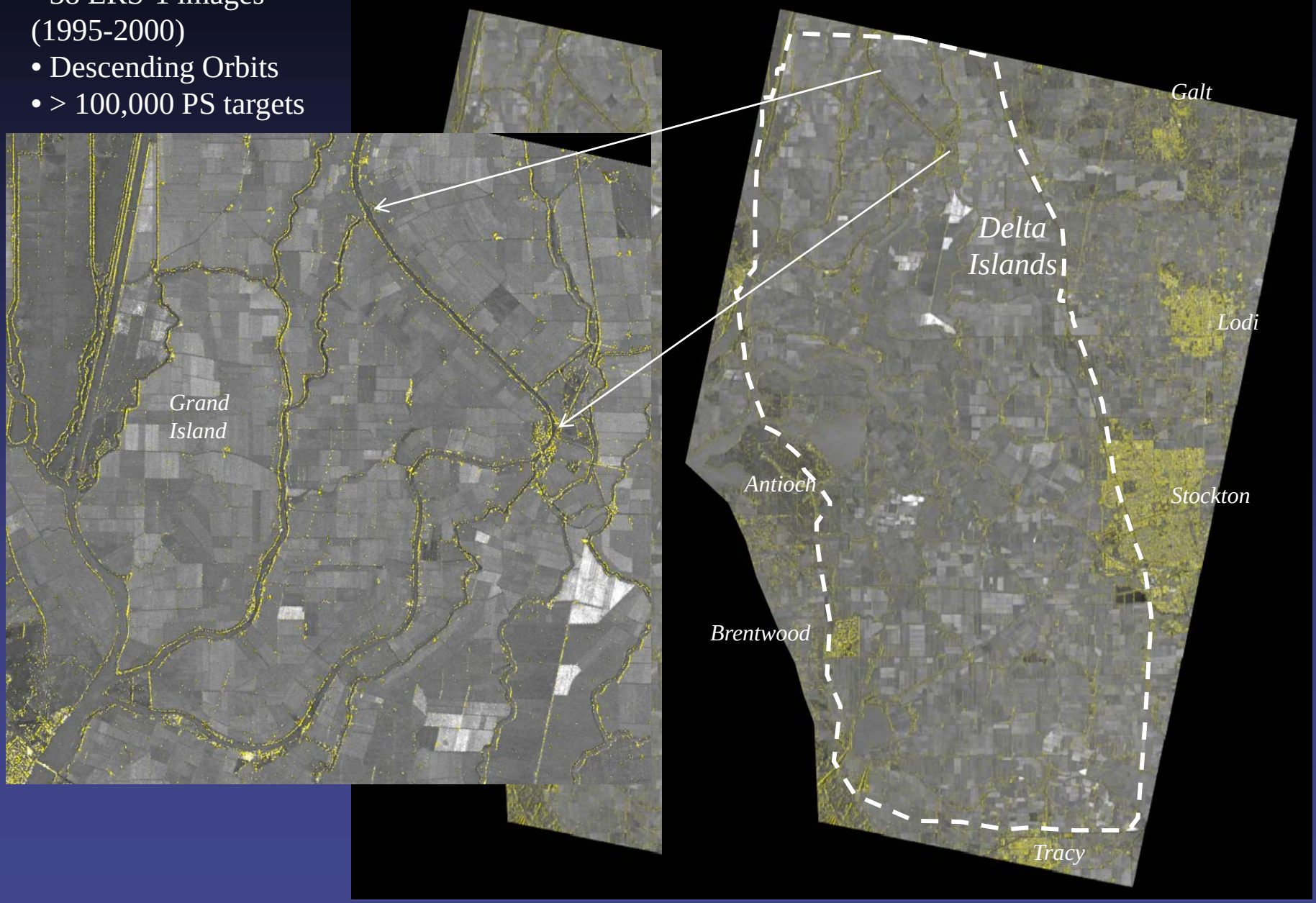



*From Dixon et al., 2006*

Levee failures correlated with highest subsidence rates

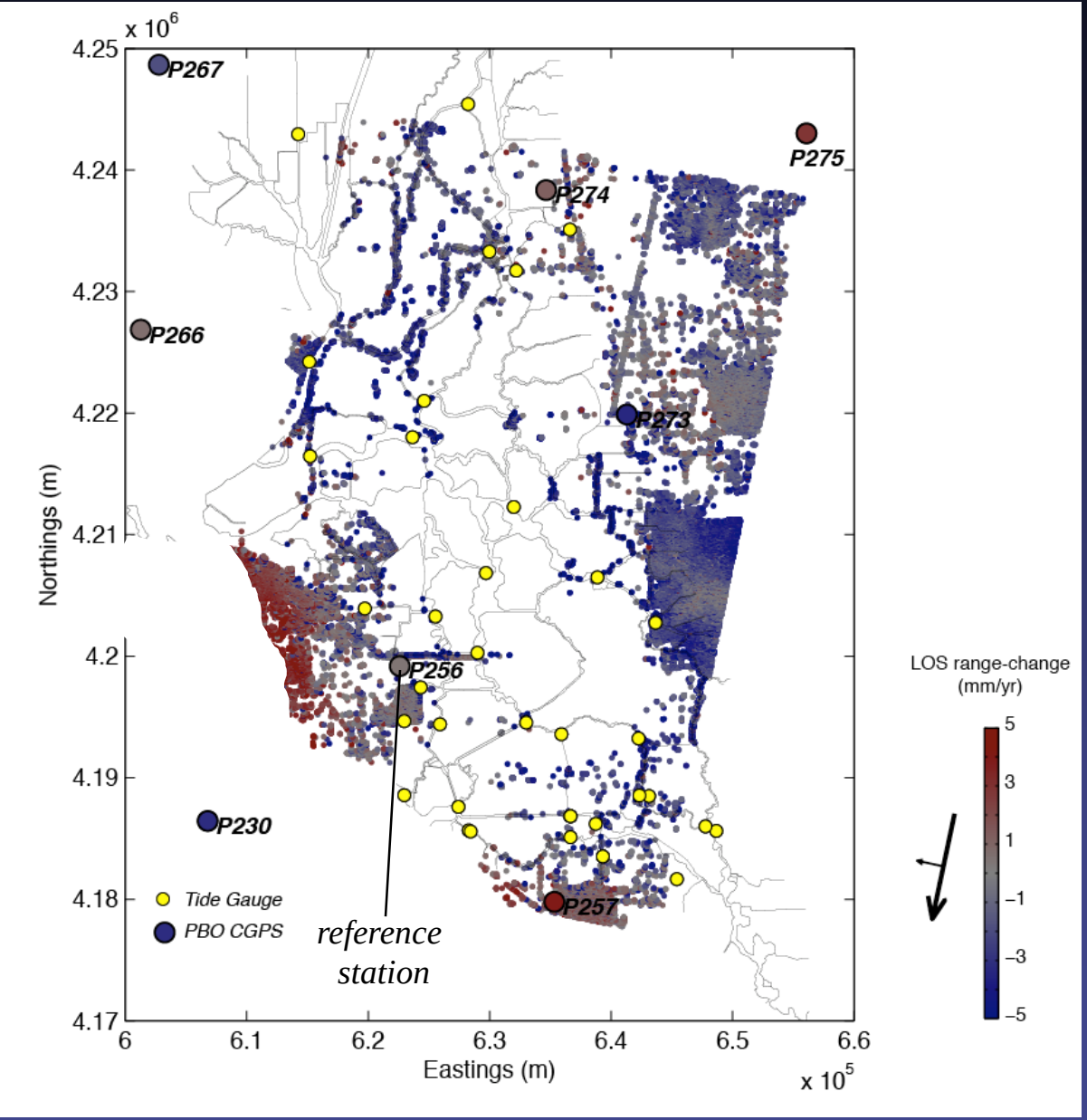
# DELTA PSINSAR TARGETS

- 38 ERS-1 images (1995-2000)
- Descending Orbits
- > 100,000 PS targets

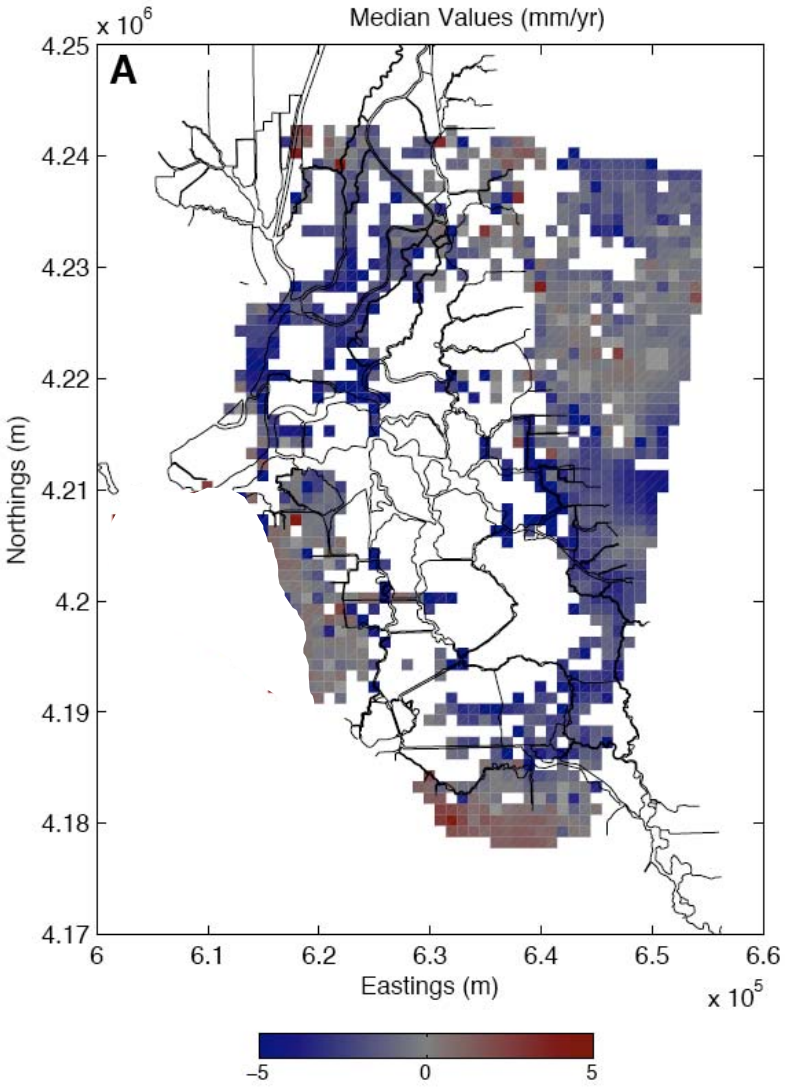


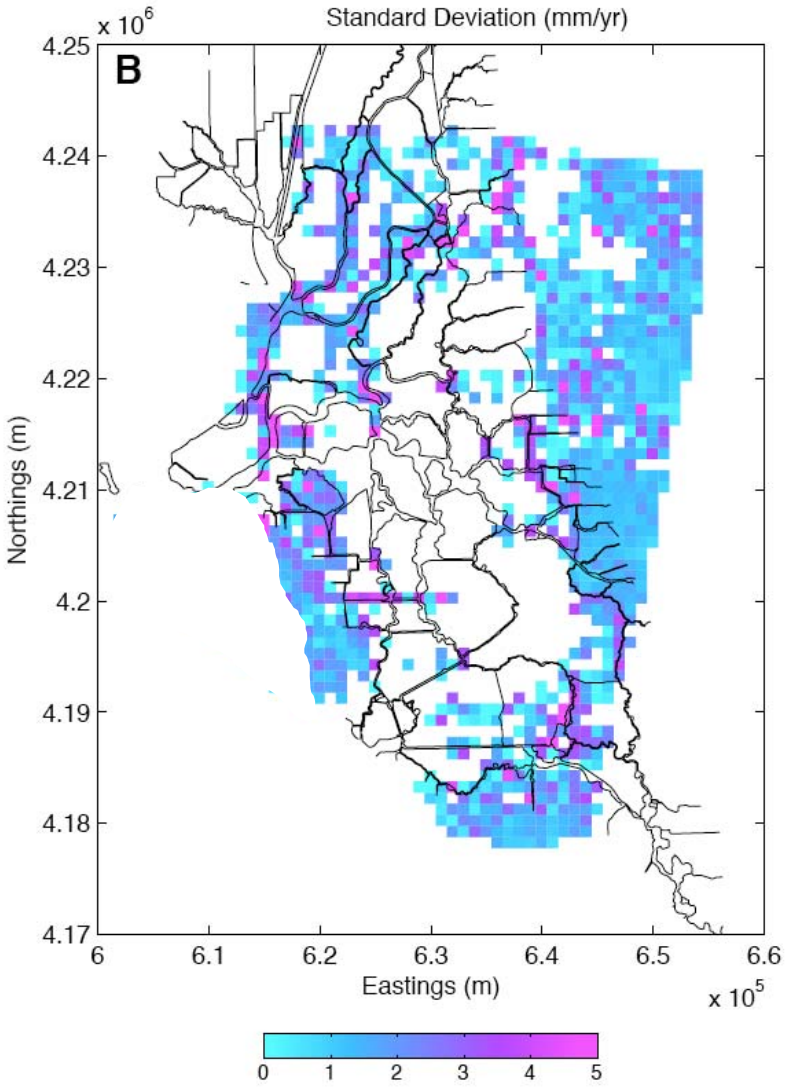
# AVERAGE LOS RANGE CHANGE (MM/YR): 1995-2000

- Signals from island margins (i.e. levee roads)
- ~ 5mm/yr could be low-biased
- slower than few cms/yr in Mount and Twiss (2005), but similar to Deverel and Rojstaczer (1996) measurements



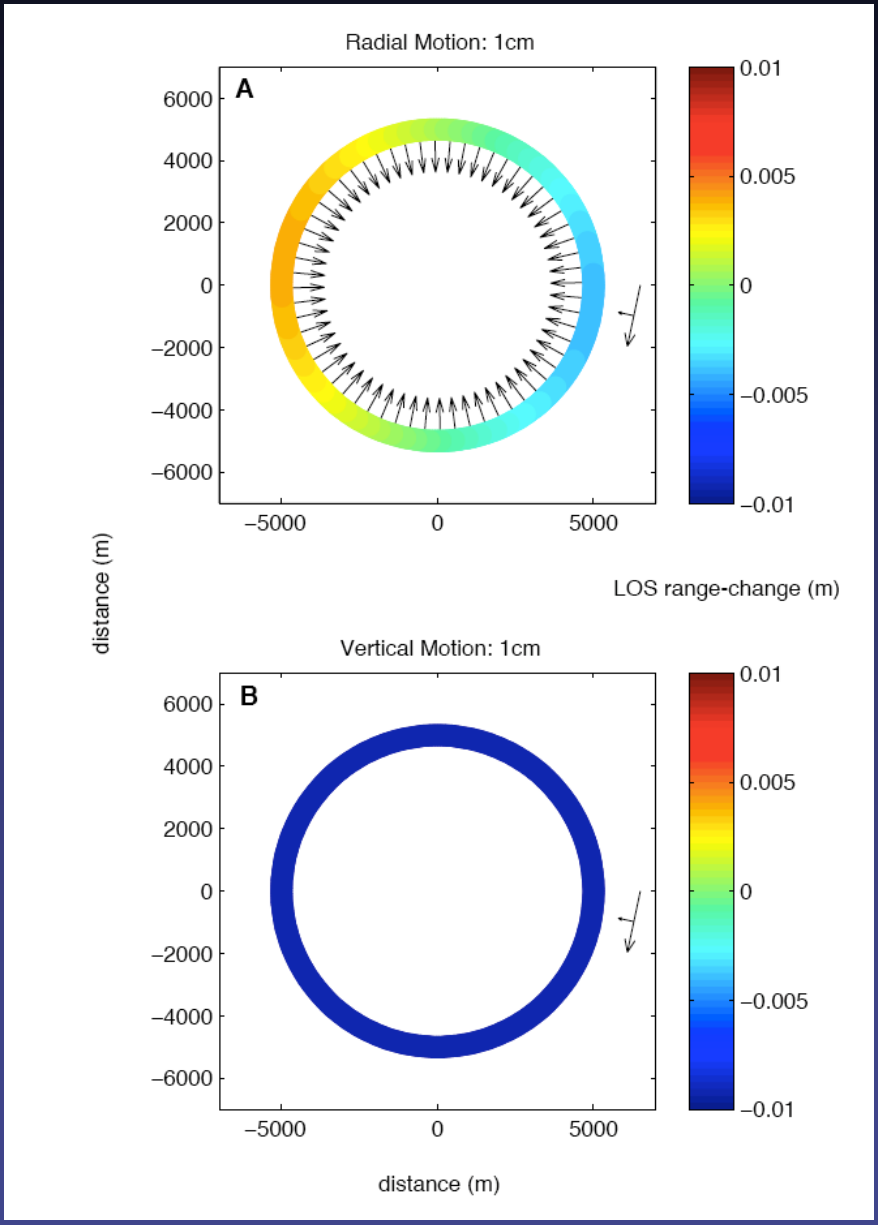
# 1KM X 1KM GRID ANALYSIS



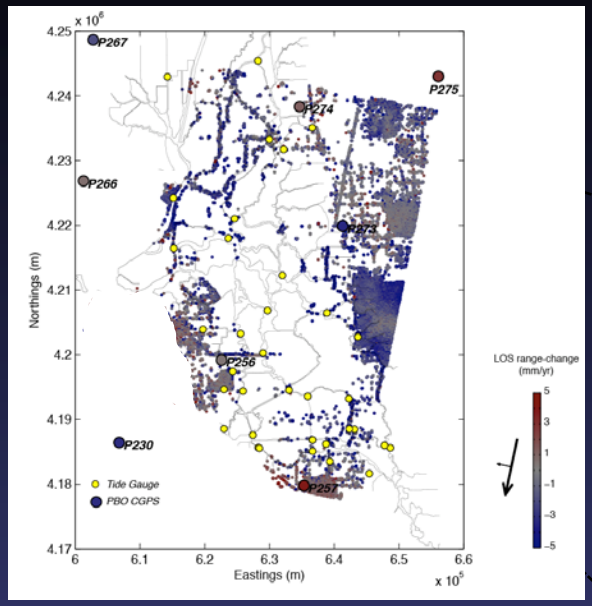



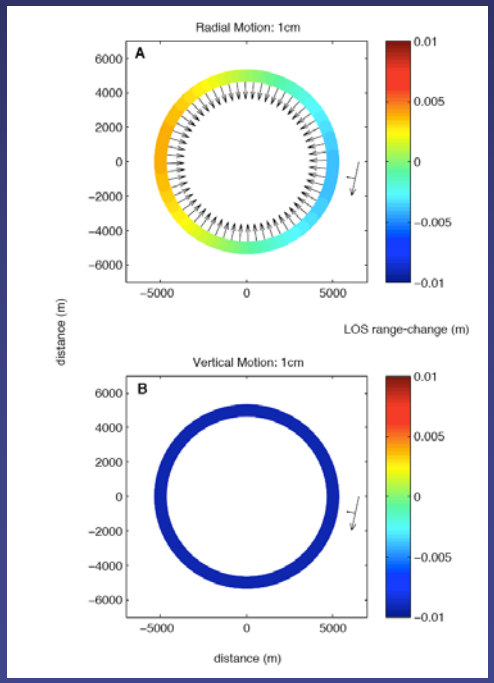
# LEVEE MOTION DETECTION FEASIBILITY

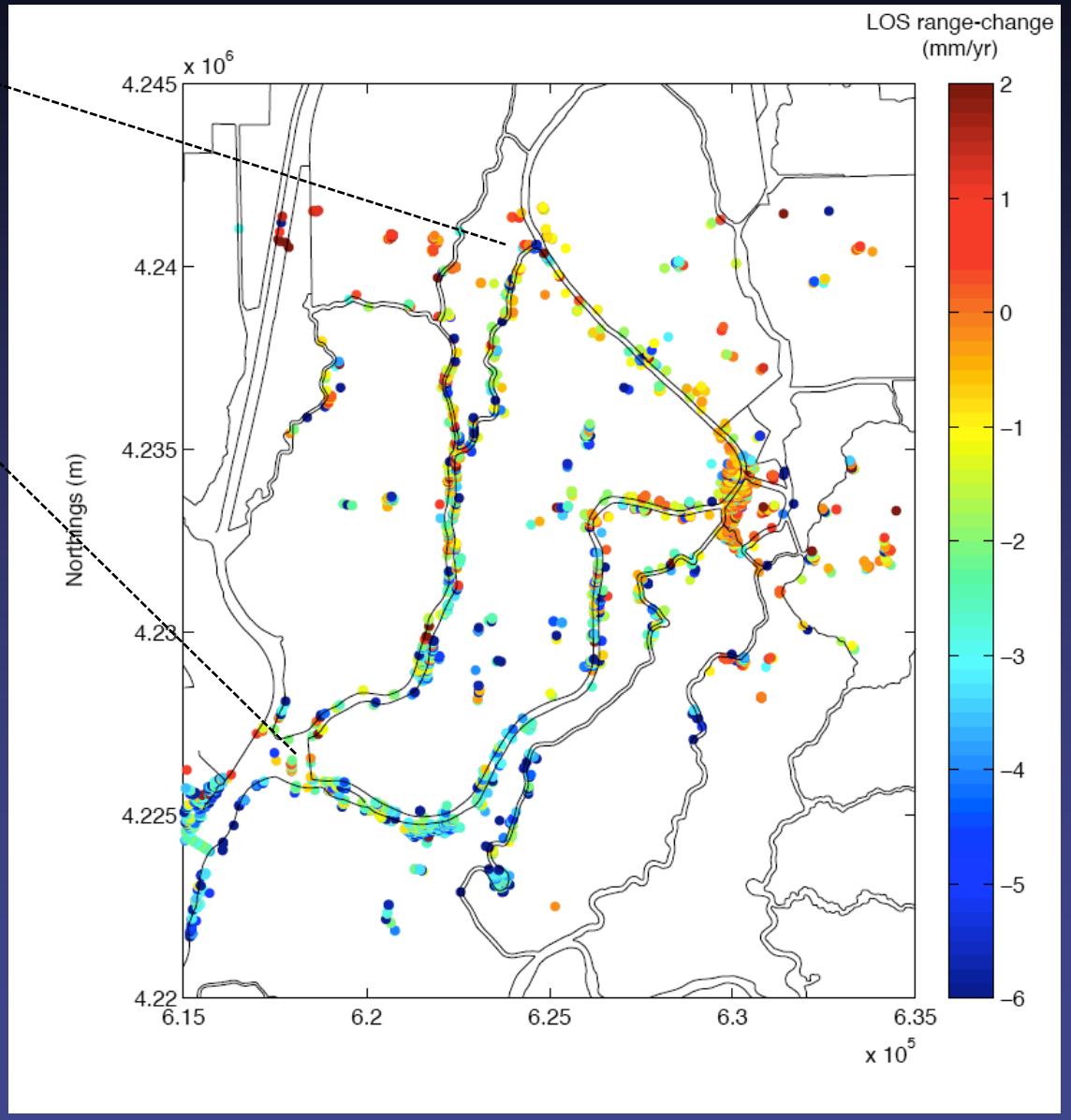
centers of levees are expected to subside more than margins



# GRAND ISLAND



# CONCLUSIONS & RECOMMENDATIONS

- InSAR method provides a synoptic view of Delta subsidence

- 1995-2000 ~ 5 mm/yr subsidence rate, suggest slowing, could be a minimum rate

- Possible detection of gradients associated with the levees

- Tide Gauge Corrections for Sea-Level Rise monitoring

- Ground-Based High Resolution Studies

*Ground-Based LiDAR Survey of Delta Levee*